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GROWTH AND MORTALITY IN A VIRGIN STAND OF PONDEROSA PINE COMPARED WITH A CUT-OVER STAND

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1/Maintained by the Forest Service, U. S. Department of Agriculture, for Arizona, New Mexico, and west Texas, with headquarters at Tucson, Arizona.

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GROWTH AND MORTALITY IN A VIRGIN STAND OF PONDEROSA PINE COMPARED WITH A CUT-OVER STAND

The immediate silvicultural task in the management of ponderosa pine for saw timber in the Southwest is the conversion of overmature virgin stands into well balanced young stands of rapid growth and high quality. This process is necessarily a slow one, involving as it does not only removal of old and undesirable trees but also their replacement by a younger generation. Moreover, substantial areas of old timber will remain uncut for another 20 years. It is possible, however, to take some of the initial steps of conversion far in advance of actual logging. Most important of these is the restocking and training of pole stands in open spaces which in some virgin forests occupy as much as 50 percent of the area.

With the object of ascertaining what changes actually take place in a natural forest under protection, a sample plot of 120 acres was established 27 years ago in what is now the Fort Valley Experimental Forest. Ten years later the area was enlarged to 160 acres, and all the trees were numbered for individual record. At the same time an adjoining newly logged area of 160 acres was also made into a sample plot and the two plots have since been carried in parallel records. Although reference is made, for certain purposes, to the older virgin stand records, this report concerns primarily the two sets of records begun in 1925.

Site and Stand Description

Site

Both plots are located within 1 mile of the Fort Valley headquarters, 9 miles northwest of Flagstaff, Ariz. The elevation is between 7,400 and 7,500 feet above sea level and the topography is gently rolling. The soil is a clay loam resulting from the disintegration of basalt. Annual precipitation averages slightly more than 23 inches. The plots are located on what is considered site 2 for ponderosa pine in the Southwest. Virgin stands on this site bear up to 20,000 board feet per acre and mature dominants attain heights of 120 to 130 feet. The site corresponds to quality IV in California and eastern Oregon.

Composition

Prior to 1924 the two stands were comparable as to merchantable volume and tree size, both containing between 11,000 and 12,000 board feet per acre. Most of the trees were in three broad age classes: yellow pines, mainly over 200 years old and making up the bulk of the volume; blackjacks and intermediates, 100 to 200 years old; a few poles under 100 years old; and a large number of seedlings mainly of 1919 origin. The cut-over plot was logged under Forest Service administration in 1924. Cutting was by the group selection system, removing about 8,000 board feet per acre, largely from the yellow pine component of the stand, and leaving 3,400 board feet.

Plot Measurements

All trees 3.6 inches d.b.h. and larger were tagged and their diameters were recorded in 1925. Both plots have since been remeasured at 5-year intervals. At each remeasurement the "new trees" (those entering the 4-inch d.b.h. class) were tagged, and those which died were noted, with the cause of death. Many other changes, difficult to measure but detected by observation, were also noted. Most important of these was natural restocking which was practically nil prior to 1913, became complete in 1919, and was reduced somewhat on the logged area in 1924.

Changes in Stand Structure

Tables 1 and 2 show number of trees and volume per acre on the two plots at the beginning and end of the 15-year period. A stand table of the cut-over area before logging is not available, but reconstruction of the stand with the aid of sale records indicates that the volumes on the two areas were nearly equal. In 1925 the total number of trees per acre is seen to be but slightly less in the cut-over than in the virgin stand. Cutting noticeably lowered the number of trees 18 inches d.b.h. and over, but as it happens the cut-over area originally had a larger number of trees below 18 inches, which almost offsets the loss in higher diameter classes.

Changes in distribution of diameter classes have been slight in the virgin stand but very pronounced in the cut-over stand. In the cut-over stand a definite stepping up of diameter classes is easily seen; many of the trees in each diameter class grew about 3 inches in diameter during the 15 years. As a result the entire column of figures under "No. trees" has, with minor changes, moved down one line in the 1940 tabulation. In addition, numerous smaller trees have entered the 9- to 12-inch class from below, bringing the total number of trees now above 8 inches in the cut-over stand to more than that in the virgin stand.

Diameter Growth

Table 3 shows the diameter growth and number of trees by d.b.h. classes in the two stands. This table brings out a striking advantage of the cut-over plot in number of trees in the lower diameter classes. Although the comparison is made 10 years after the cutting, the difference in number of small trees cannot be attributed to cutting because for diameter classes below 11 inches the growth rate after cutting is almost identical on the two areas; at 11 inches, however, growth in the cut-over stand begins to forge ahead and it maintains a definite lead to the top of the series of diameter classes.

Gross Increment

Table 4 shows the gross increment by 5-year periods. It declines noticeably in the virgin stand but only slightly in the cut-over. Only during the first period was the gross increment in board feet much higher in the virgin than in the cut-over stand. The obvious deduction is that volume of growing stock *per se* does not govern the rate of increment. A rise of increment accompanies a rise in volume of growing stock only if this means more complete utilization of the soil, especially where new trees take possession of soil space hitherto unused.

Percent of volume increment is naturally influenced by the volume base, or the principal from which the rate of increment is derived. Since the volume at the beginning of the record was three times as high in the virgin as in the cut-over stand, growth in the former would have to be three times as high in order to keep pace with the cut-over stand. Since actual gross increment was but little higher in the virgin stand, the percentage rate is roughly one-third of that in the cut-over stand.

The increment percent declined over the 15-year period because the volume base was continually rising. This was true of both plots but more so on the cut-over because net increment was higher. On this plot the volume increased by nearly 500 board feet in each 5-year period.

Mortality

Trends

Relative mortality in the two stands is shown in table 5. Obviously the cutting lowered mortality by removing trees which were in an advanced state of decline. The volume lost in the cut-over stand during the three periods has remained almost stationary; in the virgin stand, however, there was a sharp rise during the last 5-year period. Fluctuation of mortality in the virgin stand is to be expected because of the large number of highly susceptible trees. Abnormal intensity of any adverse condition such as drought, wind, or lightning may kill many of the veterans. The elimination of highly vulnerable trees during such a period tends to raise the general level of resistance, resulting in a compensating decline of mortality during the period immediately following.

Although three periods are not sufficient to establish a trend, it should be recognized that forces are at work which inevitably bring about increasing losses in both numbers and volume. As the mature components of a stand grow older and larger they become more susceptible to wind and lightning. In a previous article[3] it has been shown that only one-third of the trees which are struck by lightning die immediately or even within several years; some recover but others decline and die later. Mistletoe is an insidious enemy which works slowly but with deadly effect. In groups which have not been adequately opened up, root competition, in conjunction with drought and bark beetles, takes an increasing toll. In the course of 20 to 30 years all of these agencies working toward a common end may be expected to exert a cumulative influence in both virgin and cut-over stands. Three large cut-over sample plots on record during 25 to 30 years show some tendency toward fluctuation but also point unmistakably toward a gradually rising mortality rate.

Fluctuation rather than a continuous trend is likely to characterize virgin stands. This is indicated by a 25-year record on the original 120 acres of the uncut sample plot previously mentioned. Annual mortality by 5-year periods from 1915 to 1940, expressed in board feet per acre, was: 41, 107, 50, 40, 112. (See also table 13.)

3/ Wadsworth, Frank H. Lightning damage in ponderosa pine stands of northern Arizona. 1942. (Submitted to Jour. Forestry.)

Relation to Tree Diameter

Mortality by broad diameter classes in the two plots is shown in tables 6 and 7. In both virgin and cut-over stands the loss in the upper diameter classes is conspicuously greater than in the lower classes. Other sample plots in the Fort Valley Experimental Forest have borne out this relationship.[4] The cut-over stand with almost one-third the 1925 volume of the virgin stand suffered only one-fifth the volume loss of the latter. On a percentage basis the contrast is less striking because of the larger volume base in the virgin stand. The tables also suggest that removal of most of the trees above 20 inches d.b.h. on the cut-over plot precluded the high mortality commonly found in the larger sizes, particularly in the "31-inch plus" class, in the virgin plot, without a compensating increase of mortality in the trees of smaller diameters.

Relation to Age Classes

In tables 8 and 9 the mortality on the two plots is shown by blackjack and yellow pine separately. The higher mortality in the older age class is marked. In the cut-over plot more blackjacks and fewer yellow pines were killed than in the virgin plot. Removal of most of the yellow pines by cutting left few of them to be killed and at the same time exposed the blackjacks to wind and lightning, the two most important causes of mortality.

Because the yellow pines are generally larger than the blackjacks the difference between losses in the two stands is greater when expressed in volume than in number of trees. The ratio of loss in the virgin plot to that in the cut-over plot is 2 to 1 for number of trees and 5 to 1 for volume.

When measured in percent of either numbers or volume, blackjack mortality is much lower than yellow pine mortality in both plots. As has been pointed out, yellow pines, being taller, are more likely to be struck by lightning than are blackjacks; also, after being struck, yellow pines are more likely to die. Windfall is also more prevalent among yellow pines.

Although the mortality percent of both blackjack and yellow pine alone is higher for the cut-over than for the virgin stand, the relation is reversed when blackjack and yellow pine classes are combined. The explanation of these apparent contradictions is to be found in differences in the actual numbers of trees on which percentages are based.

Causes

Tables 10 and 11 show lightning to be the chief cause of mortality in both plots. Because lightning usually strikes the tallest and largest trees in the stand it is responsible for the loss of considerable merchantable volume. In the virgin plot 42.8 percent of the volume-loss, or 384 board feet per acre, during the 15 years of record

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4/Pearson, G. A. Mortality in cut-over stands of ponderosa pine. Jour. Forestry 37:383-387. 1939.

is attributed to lightning. In the cut-over plot the corresponding figures are 50.0 percent and 90 board feet per acre. Annual lightning losses per acre were 25.6 board feet in the virgin stand and 6 board feet in the cut-over. When it is considered that only one-third of the trees struck die at once but that nearly all deteriorate, the importance of lightning becomes more significant.

Bark beetles were responsible for a large share of the volume loss, particularly in the virgin stand where this agency ranked second among causes of death. Many of the trees were recorded as killed by a combination of either lightning and insects or mistletoe and insects. Because the most common injurious forest insects in this locality (Ips sp. and Dendroctonus valens) are usually secondary in the overstory, the associated cause is considered the primary one in this analysis. In the absence of other visible cause, the death of trees which show signs of severe beetle attack is attributed directly to the beetles. Bark beetles caused 27.3 percent of the total 15-year loss of 907 board feet per acre in the virgin plot, or 16.5 board feet per acre annually. In the cut-over plot the corresponding figures were 11.5 percent of 175 board feet or 1.3 board feet per acre annually.

Wind mortality ranks second on the cut-over and third on the virgin plot. Nearly all of the windfall occurred during the last period and contributed materially to the sharp rise in total mortality of the virgin plot. Windfall accounted for 18.2 percent of the volume loss in the virgin stand, or 11 board feet per acre annually during the 15 years. In the cut-over stand the corresponding figures were 23.2 percent and 2.7 board feet per acre annually.

Mistletoe is seen to be of little importance as a cause of mortality in these plots. Practically all the trees killed by mistletoe were small and as a result the volume loss has not been great. The local variation in the severity of mistletoe is seen in that only 3.8 percent of the volume loss in 15 years is attributed to mistletoe in the cut-over plot, as compared with 37.6 percent during 30 years in the similar cut-over Wing Mountain plot, 4 miles distant.5/

Net Increment

As shown in table 12, net increment of the virgin stand (gross increment less mortality) was consistently much below that of the cut-over stand, both in board feet and in percent. Particularly was this true in the last period when heavy windfall lowered the net increment to 3 board feet per acre per year, or 0.02 percent of the volume. The fact that mortality on the cut-over area during this final period increased only 1 board foot per acre is a tribute to silviculture. During 15 years the cut-over area has increased in volume at an average annual rate of 96 board feet per acre as compared with 48 for the uncut area.

5/Pearson, G. A., and Wadsworth, Frank H. An example of timber management in the Southwest. Jour. Forestry 39:434-452. 1941.

Other cut-over sample plots in the Fort Valley Experimental Forest have experienced a sharp and sustained decline of increment, both gross and net, after the second 5-year period; but in this instance the cut-over plot has shown no indications of a decline during the third period. Whether and how long the even course of the past 15 years will continue is a subject worthy of observation. There are two factors which may have the effect of postponing a decline. One is a modification of the usual cutting practice in group selection whereby groups of large blackjacks and intermediates were opened up considerably. Another factor is the low incidence of mistletoe on this plot.

Further Analysis of the Virgin Stand

A better view of changes and trends in the virgin stand is obtained from a 25-year record of the original virgin plot. During the first 10 years, as has been stated, the trees were not tagged and therefore a detailed analysis is not possible for this period; but for mass measurement of increment and mortality the record is adequate. Table 13 gives increment and mortality by 5-year periods from 1915 through 1940.

The first two periods register the highest gross increment and the second highest mortality of the entire series. A gross annual production of 139 board feet from 1920 to 1925 is suggestive of possibilities with mortality under control. A net annual increment of 83 board feet per acre is attained in the first period; in the third and fourth it was 66, but in the fifth mortality exceeded growth by 10 board feet. The picture as a whole is one of erratic fluctuation, which is to be expected. A stand whose volume is made up largely of mature and overmature trees would be extremely sensitive to unusual weather conditions such as a combination of high winds and waterlogged soil. A succession of dry summers might accomplish the same thing because in dense groups of old trees the reserve of soil moisture must inevitably be low. Because large, slow-growing trees are especially subject to bark beetles, it is suggested that root competition may be an important factor in insect losses.

Acceleration of growth in surviving trees might be expected to follow high mortality, but for the fact that the number eliminated is seldom sufficient to relieve competition. In individual cases, however, the remaining trees are benefited. Probably the greatest effect of mortality is to liberate the younger generation.

The common assumption that virgin stands remain stationary because growth is offset by mortality is not borne out by these records. Despite two periods of extreme mortality, the mean annual net increment during 25 years has been 47 board feet per acre. If a much larger proportion of the stand were mature, mortality might balance growth. It should be borne in mind, however, that maturity, as exemplified by the yellow pine class normally below 300 years old, does not preclude substantial growth. Yellow pines 250 years old in a group may be stagnant, but they respond to release when several members of the group are removed.

More than half of the soil is normally occupied by immature classes. A detailed map of an adjoining 80-acre tract in 1940[6] showed that only about 25 percent of the entire area was occupied by the yellow pine class, even though a border strip of 25 to 50 feet surrounding each group and extending out into thrifty reproduction was assigned to each yellow pine group. Blackjacks and intermediates occupied another 25 percent, and poles, saplings, and seedlings accounted for nearly all of the remaining space.

Blackjacks as a class make substantial diameter growth even in virgin stands. Besides, in the stand here recorded an appreciable number of poles have entered the 12-inch diameter class each 5-year period. As time goes on, this movement is going to assume large proportions because about half the total ground space is occupied by reproduction of 1919 and 1913 origin. In 1935 the trees 4 to 11 inches d.b.h. numbered 16 per acre.

Virgin stands vary greatly in density and distribution of age classes, but it can be said that rarely are mature elements utilizing more than 30 percent of the soil on areas as large as 40 acres. Where reproduction has been successful, advance of the young generation is going to alter the whole aspect of these stands. Also, in time the young trees are going to enter into sharp competition for moisture. The persistent decline of gross increment on this area since 1925 (table 13) could be attributed in part to a gradual invasion by saplings of the root zone of older trees which are known to feed far beyond the area outlined by their crown projections. It is possible to picture a temporary situation in which competition by poles and saplings may slow down the growth of the older trees without compensating for the loss in board-foot increment. But eventually, as the younger generation attains board-foot size, the increment of the stand as a whole should rise above the level existing before competition between the classes began.

Summary

1. In this investigation a virgin stand of ponderosa pine has been compared with a cut-over stand of the same species. Conclusions are drawn from measurements of diameter and records of mortality at 5-year intervals over a period of 15 years. A supplementary record of volume increment and mortality in a portion of the virgin stand is available for 25 years.

2. Virgin stands of ponderosa pine in the Southwest are capable of substantial increment because, as a rule, the greater portion of the area within such stands is occupied by immature age classes or may be practically vacant. Under protection the volume increases and the growing stock builds up in the lower diameter classes.

6/Pearson, G. A. Improvement selection cutting in ponderosa pine. 1942. Jour. Forestry 40:753-760.

3. Net increment is greatly influenced by mortality, which during short periods may equal or exceed gross increment. During 25 years the mean annual net increment on an area of 120 acres was 47 board feet per acre. Mortality fluctuated greatly when broken down into 5-year periods.

4. Removal of 70 percent of the volume under a modified form of the group selection method which opened groups of large blackjack resulted in marked stimulation of diameter growth. In the virgin stand diameter growth fell off rapidly above the 10-inch class. In the cut-over stand growth was well sustained through the 24-inch class and remained as high as 1 inch per decade in the few large trees measuring up to 37 inches d.b.h.

5. Cutting under the group selection method as here practiced has proven effective in lowering mortality. Whether lighter cutting can be made to accomplish nearly the same reduction of mortality while increasing gross increment is a subject deserving further investigation.

6. The relative order of magnitude of the toll taken by the several killing agents, expressed in percent of number of trees or volume of the stand in 1925, is as follows:

Virgin stand: lightning, bark beetles, wind, mistletoe.

Cut-over stand: lightning, wind, bark beetles, mistletoe.

7. Mistletoe ranks lower on both of these areas than on most of the sample plots in the Fort Valley Experimental Forest, and it is probably much below the average for the Coconino Plateau.

8. As on all sample plots in the Fort Valley Experimental Forest, the greatest volume loss occurs in the higher diameter classes and it is much higher for yellow pine than for blackjack.

Table 1.- Number of trees and volume per acre in the virgin stand, Sample Plot S6, 160 acres.

D. b. h. class	1925		1940	
	Trees	Volume	Trees	Volume
Inches	No.	Ft.b.m.	No.	Ft.b.m.
9-11	2.33		3.83	
12-14	2.36	143	2.85	171
15-17	2.83	375	2.51	330
18-20	3.31	833	3.28	838
21-23	3.35	1,435	3.45	1,496
24-26	2.83	2,097	2.93	2,190
27-29	2.02	2,132	2.24	2,347
30-32	1.46	2,000	1.57	2,145
33-35	0.72	1,260	0.77	1,360
36-38	0.34	766	0.37	805
39-41	0.19	505	0.19	523
42-44	0.06	181	0.08	246
45-47	0.01	24	0.01	24
48-50	0.01	27	0.01	29
Total	21.82	11,778	24.09	12,504

Table 2.- Number of trees and volume per acre in the cut-over stand, Sample Plot S7, 160 acres.

D. b. h. class	1925		1940	
	Trees	Volume	Trees	Volume
Inches	No.	Ft.b.m.	No.	Ft.b.m.
9-11	5.93		11.93	
12-14	4.18	219	5.97	300
15-17	3.73	472	4.17	542
18-20	2.61	653	3.21	780
21-23	1.76	733	2.41	1,001
24-26	0.86	558	1.53	984
27-29	0.46	425	0.65	612
30-32	0.16	196	0.31	404
33-35	0.04	62	0.08	124
36-38	0.02	67	0.02	38
39-41			0.02	47
Total	19.75	3,385	30.30	4,832

Table 3.- Diameter growth of ponderosa pine in a virgin stand compared with a cut-over stand. Sample plots S6 and S7, Fort Valley Experimental Forest, 1925 to 1935. Area of each plot, 160 acres.

D. b. h. class	Trees in class		Diameter growth1/ 1925-1935	
	Virgin	Cut-over 1935	Virgin	Cut-over
Inches	Number	Number	Inches	Inches
4	298	1,270	2.01	1.75
5	307	1,126	1.82	1.72
6	242	841	1.61	1.77
7	228	721	1.71	1.78
8	165	547	1.78	1.80
9	154	421	1.78	1.75
10	100	317	1.74	1.60
11	113	258	1.44	1.54
12	121	263	1.13	1.53
13	122	206	1.03	1.61
14	133	212	.89	1.62
15	131	233	1.00	1.61
16	147	203	.97	1.59
17	169	163	1.01	1.53
18	185	138	.99	1.59
19	171	135	.87	1.64
20	166	144	.90	1.62
21	210	95	.90	1.40
22	149	98	.86	1.44
23	166	80	.76	1.43
24	172	55	.85	1.38
25	143	41	.73	1.33
26	128	39	.68	1.34
27	98	31	.71	1.21
28	112	26	.60	1.22
29	103	10	.57	1.10
30	84	16	.54	1.35
31	70	7	.54	1.06
32	66	3	.53	1.20
33	46	4	.50	1.13
34	36	1	.53	1.70
35	26	1	.54	.90
36	20	1	.45	1.20
37	18	3	.50	1.66
38	13	0	.23	
39	16		.31	
40	7		.43	
41	7		.57	
42	4		.50	
43	3		.33	
44	1		-	
46	1		-	
48	1		1.00	

1/Not curved.

Table 4.- Periodic annual gross increment per acre and in percent of volume[1] in virgin and cut-over stands.

Forest	1925 to 1930		1930 to 1935		1935 to 1940	
	Ft.b.m.	Percent	Ft.b.m.	Percent	Ft.b.m.	Percent
Virgin	121	1.03	111	0.91	105	0.84
Cut-over	108	3.19	109	2.81	110	2.52

1/Percent of total volume at the beginning of each 5-year period.

Table 5.- Periodic annual mortality per acre and in percent of volume[1] in virgin and cut-over stands.

Forest	1925 to 1930		1930 to 1935		1935 to 1940	
	Ft.b.m.	Percent	Ft.b.m.	Percent	Ft.b.m.	Percent
Virgin	45	0.38	44	0.36	102	0.82
Cut-over	10	0.29	13	0.33	14	0.32

1/Percent of total volume at the beginning of each 5-year period.

Table 6.- Mortality in relation to tree diameter in virgin stand, Sample Plot S6, 160 acres. 1925-1940.

D.b.h. class	1925 Stand: Total: Trees	1925 Stand: Total: Volume b.m.	1925 Stand: Per acre: Trees	1925 Stand: Per acre: Volume b.m.	Mortality: Total 15 years: Trees	Mortality: Total 15 years: Volume b.m.	Mortality: Annual percent[1]: No. Trees	Mortality: Annual percent[1]: Volume b.m.
Inches	No.	Ft.	No.	Ft.	No.	Ft.	Pct.	Pct.
12-20	1,361	216,190	8.51	1,352	34	5,950	0.17	0.18
21-30	1,402	1,017,290	8.76	6,358	73	58,350	0.35	0.38
31+	356	650,920	2.22	4,068	46	80,820	0.86	0.83
12+	3,119	1,884,400	19.49	11,778	153	145,120	0.33	0.51

1/Percent of 1925 stand.

Table 7.- Mortality in relation to tree diameter in cut-over stand, Sample Plot S7, 160 acres. 1925-1940.

D.b.h. class	1925 Stand: Total: Trees	1925 Stand: Total: Volume b.m.	1925 Stand: Per acre: Trees	1925 Stand: Per acre: Volume b.m.	Mortality: Total 15 years: Trees	Mortality: Total 15 years: Volume b.m.	Mortality: Annual percent[1]: No. Trees	Mortality: Annual percent[1]: Volume b.m.
Inches	No.	Ft.	No.	Ft.	No.	Ft.	Pct.	Pct.
12-20	1,683	215,100	10.51	1,344	30	4,420	0.12	0.14
21-30	508	292,430	3.17	1,828	33	21,520	0.43	0.49
31+	21	34,130	0.13	213	1	2,280	0.32	0.44
12+	2,212	541,660	13.81	3,385	64	28,220	0.19	0.35

1/Percent of 1925 stand.

Table 8.- Mortality in the virgin ponderosa pine stand, blackjack and yellow pine separate. 1925 to 1940.

1925 D.b.h. class	Number of trees lost, per acre and percent[1]						Volume lost, board feet, per acre and percent[1]					
	Blackjack		Yellow pine		Total		Blackjack		Yellow pine		Total	
Inches	No.	Pct.	No.	Pct.	No.	Pct.	Ft.	Pct.	Ft.	Pct.	Ft.	Pct.
12-20	0.09	1.39	0.12	5.94	0.21	2.47	14	1.46	23	5.96	37	2.74
21-30	0.04	1.50	0.42	6.90	0.46	5.25	19	1.29	346	7.08	365	5.74
31+	–		0.28	12.78	0.28	12.61			505	12.54	505	12.41
12+	0.13	1.41	0.82	7.96	0.95	4.87	33	1.33	874	9.40	907	7.70

1/Percent of 1925 stand.

Table 9.- Mortality in the cut-over ponderosa pine stand, blackjack and yellow pine separate. 1925 to 1940.

1925 D.b.h. class	Number of trees lost, per acre and percent[1]						Volume lost, board feet, per acre and percent[1]					
	Blackjack		Yellow pine		Total		Blackjack		Yellow pine		Total	
Inches	No.	Pct.	No.	Pct.	No.	Pct.	Ft.	Pct.	Ft.	Pct.	Ft.	Pct.
12-20	0.15	1.34	0.03	6.52	0.18	1.71	22	1.74	5	6.17	27	2.01
21-30	0.10	4.52	0.11	11.46	0.21	6.62	44	3.73	90	13.89	134	7.33
31 +	0.00	0.00	0.01	8.33	0.01	7.69	0	0.00	14	7.11	14	6.57
12 +	0.25	2.04	0.15	9.74	0.40	2.90	66	2.68	109	11.77	175	5.17

1/Percent of 1925 stand.

Table 10.- Fifteen-year mortality in the virgin stand, by causes.
Percent[1] of number and volume b.m. killed by different agencies, 1925-1940.
Sample Plot S6, 160 acres.

D.b.h. class	Lightning		Wind		Bark beetles		Mistletoe		Unclassified		Total	
	No. trees	Volume b.m.	No. trees	Volume b.m.	No. trees	Volume b.m.	No. trees	Volume b.m.	No. trees	Volume b.m.	No. trees	Volume b.m.
Inches	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
12-20	0.4	0.4	0.5	0.6	0.8	0.8	0.3	0.3	0.5	0.6	2.5	2.7
21-30	1.4	1.9	1.4	1.3	2.0	2.0	0.1	0.1	0.3	0.4	5.2	5.7
31 +	6.3	6.4	1.8	1.7	2.7	2.7	0.4	0.3	1.4	1.3	12.6	12.4
12 +	1.5	3.3	1.0	1.4	1.6	2.1	0.3	0.2	0.5	0.7	4.9	7.7
Percent of total mortality												
	30.6	42.8	20.4	18.2	32.7	27.3	6.1	2.6	10.2	9.1	100.0	100.0

[1] Percent of 1925 stand.

Table 11.- Fifteen-year mortality in the cut-over stand, by causes.
Percent[1] of number and volume b.m. killed by different agencies, 1925-1940.
Sample Plot S7, 160 acres.

D.b.h. class	Lightning		Wind		Bark beetles		Mistletoe		Unclassified		Total	
	No. trees	Volume b.m.	No. trees	Volume b.m.	No. trees	Volume b.m.	No. trees	Volume b.m.	No. trees	Volume b.m.	No. trees	Volume b.m.
Inches	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
12-20	0.5	0.8	0.2	0.2	0.1	0.2	0.4	0.4	0.5	0.4	1.7	2.0
21-30	4.1	4.4	1.3	1.2	0.6	0.9			0.6	0.8	6.6	7.3
31 +			7.7	6.6							7.7	6.6
12 +	1.3	2.6	0.5	1.2	0.3	0.6	0.3	0.2	0.5	0.6	2.9	5.2
Percent of total mortality												
	44.8	50.0	17.2	23.2	10.4	11.5	10.4	3.8	17.2	11.5	100.0	100.0

1/ Percent of 1925 stand.

Table 12.- Periodic annual net increment in volume per acre and in in percent[1] in virgin and cut-over stands. 1925 to 1940.

Forest	1925 to 1930		1930 to 1935		1935 to 1940		Mean 1925 to 1940	
	Ft.b.m.	Pct.	Ft.b.m.	Pct.	Ft.b.m.	Pct.	Ft.b.m.	Pct.
Virgin	76	0.65	67	0.55	3	0.02	48	0.41
Cut-over	98	2.90	96	2.48	96	2.20	96	2.84

1/Percent of total volume at beginning of period.

Table 13.- Increment and mortality by 5-year periods in a virgin stand of ponderosa pine, 1915 to 1940.

	Annual increment or loss in board feet per acre				
	1915-20	1920-25	1925-30	1930-35	1935-40
Gross increment	124	139	116	106	102
Mortality	41	107	50	40	112
Net increment	83	32	66	66	-10
				20 yrs.	25 yrs.
Mean net increment in board feet per acre				62	47
Mean net increment percent				0.57	0.43